REMARKS

In the office action, the examiner rejects all claims under 35 U.S.C. §103(a). The applicants respectfully traverse the rejections with the following argument.

Claims 1 and 11

Claim 1 is rejected as unpatentable over Duren (US 6678207) over Yang (4,153,134). The Examiner states that "Duren discloses wherein a reflected up-going wave and a down-going wave combine to form a third down-going wave." (Col. 9, line 60 to col. 10, line 30) The examiner then observes that Duren does not disclose a method of generating waves, and he cites col. 2, lines 18-35 of Yang to fill this void.

According to the examiner, Yang teaches "generating an up-going and down-going wave with opposite polarity." Contrary to the examiner's assertion, there is nothing in Wang about the polarity or relative phases of the downward component of his pressure pulse relative to any other component. Instead, the pressure pulse disclosed by Yang is just a version of the traditional "isotropic source" (page 3, line 14, present application). As shown in Fig. 3 of the present application, all portions of the spherical wave front (emanating from source **31**) are in phase with one another, regardless of direction – until an event such as reflection of the up-going part of the wave front by the air-water interface, which reverses the polarity, meaning the (now down-going) wave is 180° out of phase (the condition for maximum cancellation, i.e. destructive interference) with the initial down-going portion of the wave front. This cancellation, which reduces low frequency energy, is what the present invention is designed to avoid. But this cancellation will occur in Yang's method. He teaches no way to make the pressure pulse non-isotropic, because he has no interest in that. Instead, his purpose is to make the pressure pulse die out relatively slowly and without appreciable oscillations. [Abstract, first line; and Col. 3, lines 35-36]

The applicants respectfully point out that in the case of an isotropic source such as Yang's, the up-going part of the spherical wave has particle velocity directed upward, and the down-going part has particle velocity directed downward. That might seem to suggest that Yang's up-going and down-going waves have "opposite polarity" (quote from claim 1 of the present application). That would be an incorrect

analysis. *Polarity* as applied to two waves refers to their phase relative to each other; if they are in phase, they would combine constructively, but if out of phase they combine destructively. Particle velocity can be used to determine phase, but for phase purposes the velocity must be taken relative to the direction of wave propagation. For an isotropic source, the up-going wave component has particle velocity vector aligned with the wave propagation velocity vector. The same is true for the down-going wave. Therefore, the up-going wave and the down-going wave from an isotropic source such as Yang teaches have the <u>same</u> polarity and phase.

Thus Yang neither teaches "generating an up-going and down-going wave with opposite polarity" [claim 1, present application], nor enables how to do that. Neither, of course, does Duren, as the examiner admits. Hence, Duren + Yang cannot make claim 1 obvious because this feature of claim 1 is not disclosed or even suggested in either reference.

The cited passage in Duren discloses general wavefield expressions for up-going and down-going wavefields representing the complexity illustrated in Fig. 2, as indicated at col. 7, line 62 to col. 8, line 1 combined with the discussion of Fig. 2 beginning at col. 2, line 49. Nowhere does Duren suggest that the source should be non-isotropic, or teach how this might be accomplished.

Independent claim 11 is also rejected as obvious in view of Duren + Yang. The preceding traversal argument applies equally to claim 11. Assuming the applicants are correct in their traversal of the rejections of independent claims 1 and 11, the claims depending from those claims, i.e. claims 2-5 and 12-25, are patentable as claims depending from a patentable independent claim.

Claims 6 and 26

Independent claims 6 and 26 are rejected based on Barber, col. 6 lines 25-35. That passage states:

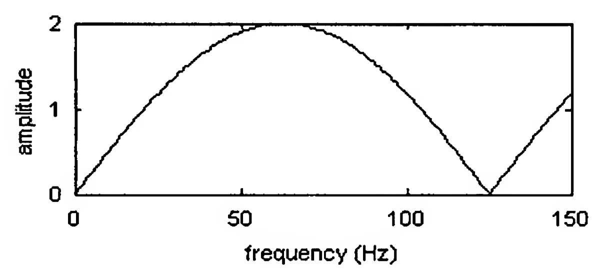
> "In either configuration, preferably the air guns **12** are disposed at a relatively shallow depth such as one to four meters below the air/water interface to minimize reflection of ghost echoes and bubble pulsation."

The examiner evidently infers that this Barber passage is teaching a "blow-out" condition as taught in paragraphs 44-45 of the present application. However, the applicants note that Barber never teaches that "the up-going wave . . . has enough energy to break through the surface of the water into the atmosphere." (Claim 6) It should not be inferred that placement of the source at a depth of one to four meters implies teaching to create a blow-out condition, i.e. a condition where substantially all the up-going wave energy is lost to the atmosphere leaving a negligible downward reflected wave. Instead, Barber's shallow placement has quite a different purpose that is more consistent with the full disclosure in Barber, as will be explained next.

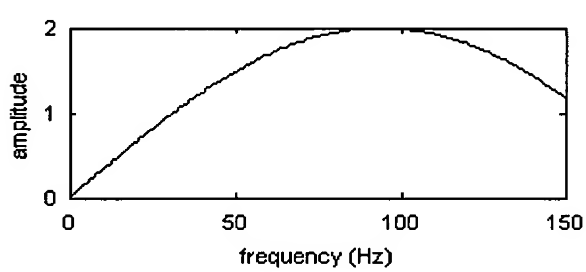
Barber is essentially describing a relatively low power seismic source (in spite of the phraseology "powerful broadband pulse" used in col. 2 line 37) for use in high resolution, repeatable (4D) seismic experiments. One embodiment describes a source array consisting of 80 cubic inch total gun volume (eight guns of 10 cubic inch volumes each) and total output of 10 bar meters peak-to-peak. See col. 2 lines 50-60. In contrast, typical source arrays used in seismic exploration have total gun volumes ranging from 2000 to 4000 cubic inches with total output often exceeding 100 bar meters peak-to-peak. A source of the power that Barber specifies would not be expected to cause blow-out, even at a depth of one meter. Nothing in Barber suggests otherwise.

As stated in the passage quoted above from col. 2, line 37, Barber's objective is broadband pulses. The applicants believe that the actual meaning of col. 6 lines 30-35 is that because of ghosting effects, Barber is driven to locating the source at increasingly shallower depths in order to obtain increasingly more broadband pulses. This is a well known phenomenon that affects high resolution seismic survey designs, as will be explained in more detail below. The reality is that in order to **avoid** blow-out conditions (the conditions the applicants are seeking to exploit in claims 6 and 26), Barber is forced to smaller sources with smaller outputs. Also, Barber describes disposing the source array at relatively shallow depths such as one to four meters below the air/water interface to minimize bubble pulsation (col. 6, line 35). In a blow-out condition, bubble pulsation is not an issue because the bubble is expelled from the water into the air without pulsation.

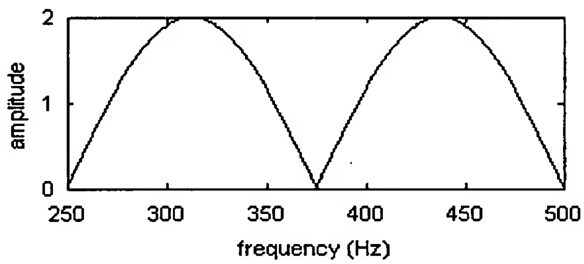
The reason why shallow source location produces a broader band pulse is connected with the ghost echo. The ghost echo has a frequency dependent effect. Changing source depth is a means to minimizing or maximizing the effect for desired frequency ranges. (This is well known and commonly exploited - including in the design of seismic surveys.) For example, assume a standard "isotropic" or monopole source at a typical towing depth of 6 meters. A graph of the resulting ghosting function follows, with "ghosting function" meaning the total down-going signal, i.e. the ghost combined with the original down-going component:



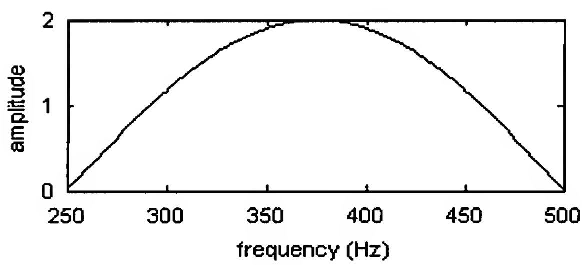
If it were wanted to emphasize higher frequencies (as sometimes is the case in high resolution surveys), one would choose a more shallow source depth, say 4 meters, resulting in the following ghosting function:



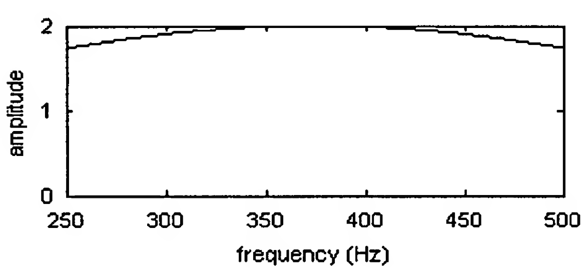
Barber appears to be interested in yet higher frequencies, and the increased bandwidth that results from their acquisition. He states "usable data acquisitions in frequencies as high as 1 kHz" in the embodiment with a 7.1 peak-to-peak bar meter output (col. 2, lines 55-65). It seems reasonable to assume that describes an extreme of the best cases, and therefore that frequencies less than 1kHz and greater than 100 Hz are the of the order Barber might typically design for. Selecting the frequency range 250 to 500 Hz to examine source depth effects, a graph of the ghost function in this frequency range for a conventional 6 meter source depth:



The notch at 375 Hz can be removed if the source depth is halved to 3 meters:



Reducing the source depth to 1 meter further enhances the energy in this frequency range:



All ghosting function graphs above were generated using the modulation function for the isotropic, or monopole, source; see equation (4) in the present application.

Thus, it can be seen that the actual meaning of col. 6 lines 30-35 is that because of ghosting effects, Barber is driven to locating the source at increasingly shallower depths in order to obtain increasingly more broadband pulses.

If instead Barber were truly pursuing blow out conditions, why does he reduce to such small sources with small power outputs? Blow outs further reduce radiated

power. So a small source used under blow out conditions is putting very little energy into the earth at any frequency.

Thus, Barber nowhere teaches the feature of claims 6 and 26, that:

> *the up-going wave is created substantially near the surface of the water and has enough energy to break through the surface of the water into the atmosphere, thereby there is no significant wave reflected off the surface of the water and the first down-going wave is the only significant wave produced by the source.*

Moreover, what Barber is actually saying at col. 6, lines 30-35 is readily explained as directed to an objective completely different from a blow-out condition. Accordingly rejection of claims 6 and 26 based on Barber is improper, and claims depending on claims 6 and 26 are patentable also as claims depending on a patentable independent claim.

Claim objections

The objections to claims 27 and 28 are dealt with in the amendments to the claims where the correction suggested by the examiner is made. The applicants appreciate the examiner's pointing out this mistaken reference to the *method* of claim 26 when claim 26 is an *apparatus* claim.

Regarding claims 7 and 9, the examiner suggests that the feature "pressure gradient sensor" in claim 9 seems to contradict the "motion sensor" limitation. Attention is directed to paragraph 30 of the application, specifically lines 1-2 on page 9, where it is stated that "a motion sensor . . . might measure the gradient of pressure and take advantage of the fact that the gradient of the pressure can be related to motion." The applicants believe that this supports claim 9 without any amendment.

CONCLUSION

Each of the applicants' claims relates to a marine seismic source method or seismic source apparatus, and the claims of the application are believed to be patentably distinct from all known prior art, including all art cited by the examiner. Therefore, the applicants respectfully request allowance of all pending claims.

Respectfully submitted,

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J. Paul Plummer

J. Paul Plummer
Reg. No. 40,775

ExxonMobil Upstream Research Company
P.O. Box 2189
Houston, Texas 77252-2189
Telephone: (713) 431-7360
Facsimile: (713) 431-4664

Certification under 37 CFR §§ 1.8(a) and 1.10

I hereby certify that, on the date shown below, this application/correspondence attached hereto is being:

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